NASA Glenn Available Software

NASA relies heavily on modeling and simulation to design, test, and refine many of its mission components. Review here some of Glenn Research Center's pioneering advancements and learn about technology and partnership opportunities in emerging and innovative operating environments. Additional software packages are available for download from the Glenn Software Repository at: https://technology.grc.nasa.gov/software/

Simulation Program Features Optimized Trajectory Performance Studies

Optimal Trajectories by Implicit Simulation, version 4 (OTIS4) is a general purpose

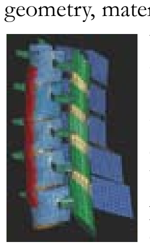
program used to perform trajectory performance studies. Though geared initially to provide sophisticated trajectory simulations for aerospace vehicles, OTIS4, a free program, can analyze a wide variety of vehicles, including aircraft, missiles, re-entry vehicles, hypervelocity vehicles, satellites, and interplanetary vehicles. It is a point mass, three degree of freedom (3DOF) simulation program for single vehicles. Options allow 6DOF simulations and several types of special multiple vehicle problems. Data obtained using OTIS4 will allow a variety of studies to be accomplished including vehicle and subsystem design trades, guidance studies, error analyses, and mission planning. OTIS4's highly generalized modeling capabilities allow the development of a progressively more detailed simulation as the vehicle and mission design advance, without abandoning the basic simulation framework. OTIS4 was the winner of the NASA 2008 Software of the Year and 2009 R&D 100 awards.

Propulsion Simulation Tool Analyzes Aerothermodynamic Behavior

The *Numerical Propulsion System Simulation* (NPSS) object-oriented architecture allows an engineer to numerically assemble a complex system comprised of differing dimensionality component codes (Numerical Zooming) and different disciplines executed on distributed heterogeneous platforms, to bring a design closer to the final configuration before hardware is ever built and tested. An estimated 55 percent reduction in the time to perform engine system simulation throughout the product life cycle may be realized, translating into a projected annual savings of over $50 million/year from increased productivity to the U.S. aircraft industry alone. Numerical zooming of multidiscipline codes of varying fidelity early in the design process increases accuracy and confidence in the design, mitigating risk and increasing safety for aeronautics and space exploration.

Probabilistic Program Simulates Variations of Structures Under Stress

Numerical Evaluation of Stochastic Structures Under Stress (NESSUS® software) is a general purpose, probabilistic analysis program that simulates variations and uncertainties in loads, geometry, material behavior, and other



user-defined inputs to compute probability of failure and probabilistic sensitivity measures of engineered systems. Probabilistic analyses predict the reliability of engineered systems and identify important design and manufacturing variables. Because the NESSUS software is interfaced to all major commercial finite element programs and includes unique capabilities for analyzing computational problems, it has been incorporated to initiate solutions in aerospace, gas turbine engines, biomechanics, pipelines, defense, weaponry, and infrastructures. Version 8 allows NESSUS software to be tailored for specific computer systems and includes a distributed parallel processing capability to efficiently analyze complex problems. NESSUS software was the winner of a 2005 R&D 100 award.

Propulsion Simulator Develops Engine Health Algorithms

Commercial Adaptation Yields Range of Propulsion Applications

The *Modular Aero-Propulsion System Simulation* (MAPSS) is a flexible turbofan engine simulation environment that provides a platform to develop advanced control algorithms governing engine health and control parameters. MAPSS is also able to generate state-space linear models to aid in controller design. The engine model is a generic high-pressure ratio, dual-spool, low-bypass, military-type, variable cycle turbofan engine with a digital controller. The commercial version (C-MAPSS) simulates transient operation of a commercial turbofan engine and provides tools for performing open- and closed-loop transient simulations and comparison of linear and non-linear models through the full range of flight conditions.

Program Predicts Ice Growth on Aircraft Surfaces in All Weather Conditions

The aeronautics community uses the *LEWis ICE Accretion Program* (LEWICE) to predict ice growth under any meteorological conditions for any aircraft surface. The atmo-

spheric parameters of temperature, pressure, and velocity, and the meteorological parameters of liquid water content, droplet diameter, and relative humidity are specified and used to determine the shape of ice accretions. Ice shape predictions

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help scientists assess performance degradation by serving as both an input to a computational fluid dynamics program and experimentally in flight or wind tunnel testing.

Software Suite Designs, Analyzes Composites and Laminates

A combination of analysis programs within the *Integrated multiscale Micromechanics Analysis Code* (ImMAC) software suite is used to design and analyze polymer-, ceramic-, and metal-matrix composites and laminates. The framework of the ImMAC suite simulates the nature of fiber breakage in composites, circumventing the need for complex models to operate on the macro scale for nonlinear composite analysis. The suite has three primary programs: Micromechanics Analysis Code with Generalized Method of Cells (MAC/GMA, to determine the effective properties and response of composites), Finite Element Analysis (FEAMAC, to enable structure analysis), and HyperMAC (to integrate core capabilities).

Modeling Code Predicts Flutter, Stress in Turbomachinery

TURBO-AE is a computer code that enables detailed modeling of aeroelastic and aerodynamic turbomachinery characteristics for prediction of flutter, forced response, and blade stress. The code reduces design cycle times by allowing new blade designs to be verified for aeroelastic soundness before resources are allocated to build and test the blades. With this prediction capability, it is possible to build thinner, lighter, and faster rotating blades without encountering problems such as stall flutter and high-cycle fatigue caused by forced vibrations.

Software Assesses ISS Power System Capability

Detailed operational timelines for the International Space Station's electrical power system are analyzed and predicted by *System Power Analysis for Capability Evaluation* (SPACE) software. SPACE incorporates orbit mechanics, electrical and battery performance, and power management within a flexible architecture that features data-driven configurations, source- or load-driven operation, and event scripting. SPACE also predicts the amount of power available for system configuration, spacecraft orientation, and solar array-pointing conditions. It is the sole tool used to conduct assessments for ISS power system capability.

Platform Provides Multi-Signal Processing Techniques for Waveform-based NDE Methods

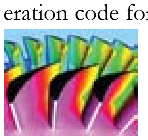
Multiple signal and image-processing techniques for waveforms and images are available with the *Non-Destructive Evaluation Wave and Image Processor* software. The platform provides advanced signal and image processing, analysis, and visualization capabilities to health monitoring engineers and scientists. The software is especially useful for broadband waveform-based scan data such as that from ultrasonic, terahertz, microwave, and radar methods. Image data from computed tomography, thermography, shearography, and acoustography can be opened and processed.

CFD Code Analyzes 3D Turbomachinery Flows

Swift is a multi-block computational fluid dynamics code for analyzing three-dimensional flows in turbomachinery. The code solves thin-layer Navier-Stokes equations using explicit finite-difference techniques. It can be used to analyze linear cascades or annular blade rows, with or without rotation. Its limited multi-block capability can be used to model tip clearances and multistage machines.

Code Generates 3D Grids for Turbomachinery Blades

Turbomachinery C-GRID (TCGRID) is a three-dimensional grid generation code for turbomachinery

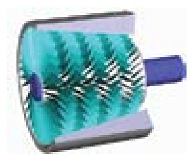


blades. It can generate single or multi-block grids that are compatible with various analysis codes including *Swift* and *Advanced Ducted Propfan Analysis Code* (ADPAC). Single-block grids can be either C-type or H-type, and can be for linear cascades or annular blade rows. Multi-block grids use C-type grids around the blade, and can have an H-grid in the inlet region and O-grids in the hub or tip clearance regions.

Streamline Analysis Code Designs Axial-Flow Compressors

Companion Code Features Off-Design Performance

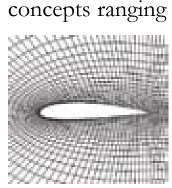
Axial-flow Compressor Design (ACD) is a streamline analysis code for the aerodynamic design of multistage axial-flow compressors. This solu-



tion provides velocity diagrams on the streamlines at the blade-row edges, and blade elements are defined by a centerline curve and a thickness distribution. The blade-element inlet and outlet angles are established through empirical incidence and deviation angle adjustments to the velocity diagrams. A companion code, *Axial-Flow Compressor Off-Design* (ACOD), is for off-design performance, and the flow and blading are modeled in a similar manner. Losses are modeled with blade-element pressure-loss coefficients as functions of diffusion factor and added shock loss.

CFD Tool Examines Low-Bypass Ratio TurboFans, Propfans

The *Advanced Ducted Propfan Analysis Code* (ADPAC) is a computational fluid dynamics tool to investigate turbomachinery concepts ranging from low bypass



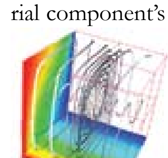
ratio turbofans to propfans. The program is based on a flexible multiple-block grid discretization scheme that permits coupled two-dimensional and three-dimensional mesh block solutions with application to a wide variety of geometries. Aerodynamic calculations are based on a four-stage Runge-Kutta time-marching, finite volume solution technique with added numerical dissipation.

Software Characterizes Microgravity Environment for Space Experiments

Researchers use the *Microgravity Analysis Software System* (MASS) to characterize the microgravity environment for space-based science experiments and study the unique behavior of organisms and the physics of fluids and materials. MASS adds value to space experiments by documenting laboratory conditions for projects in the disciplines of biotechnology, combustion, vehicle dynamics, spacecraft fire safety, and microgravity measurement programs. Beyond space, MASS may bring a better understanding to lowering vehicle exhaust emissions, increasing fire safety, and improving fuel economy for automobiles and aircraft.

Program Studies Reliability of Brittle Materials

The reliability and life of structures made from advanced ceramics and other brittle materials such as glass, graphite, and intermettalics are the focus of the *CARES/Life* software. The program predicts the probability of a brittle material component's failure versus



its service life and combines research in the areas of fracture analysis, probabilistic modeling, model validation, and brittle structure design with extensive computational capabilities into one comprehensive package to perform computer simulations prior to costly component production.

For More Information

If you would like additional information about Glenn's technology transfer opportunities, please contact:

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